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Some Observations on Relative Approaches to Visual Acquisition Modelling.

PREPARED BY

I. Overington
Human Factors and Vision Research Dept.

AUTHORISATION

S. J. H. bard
Head of Human Factors and Vision Research Dept.

BRITISH AEROSPACE DYNAMICS GROUP

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SUMMARY

For Trinational activities it is necessary eventually to agree on form of acquisition modelling to be used for system assessment. Two types of modelling are available, MRTD/Johnson criteria or ORACLE/CYCLOPS. Also two distinctly different types of assessment are necessary - comparison of existing systems and specification of future systems to meet GST's. The report discusses the relative status of the models, and the requirements of models to fulfil the two tasks. It is concluded that a form of MRTD modelling, starting from either an NVL-based or ORACLE-based foundation, is adequate for routine comparison of existing systems. For specification of future systems a much more rigorous approach is necessary, involving search and peripheral vision. Such an approach is indicated to be available through the B.Ae.D. suite of visual performance models.

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1. INTRODUCTION

For Trinational activities an eventual agreement has to be reached on forms of acquisition modelling to be used for system assessment. Two types of modelling approach are potentially available - MRTD (for thermal images) or equivalent bar pattern response together with the Johnson criteria (Ref.1), or the B.Ae.D. ORACLE/CYCLOPS approach (e.g. Ref.2). Also two distinctly different applications of modelling are necessary - comparison of existing systems and specification of future systems to meet G.S.T.'s.

2. STATUS OF MODELS

The status of the models is as follows :-

i) The MRTD approach, in particular, has been employed by a variety of laboratories, with the result that many facilities exist for both computation and measurement. The ORACLE/CYCLOPS approach has been limited in practical use to B.Ae.D. and RARDE in the UK. It normally relies for input on objective system performance measures - MTF, NETD, gain.

ii) The MRTD approach relies on the accuracy and universality of the Johnson criteria to relate it to practical field thresholds. It also assumes that in field use <u>either</u> the temperature window is very small, thus yielding a high display noise level <u>or</u> that performance is not affected by display gain. The latter of these assumptions most certainly is not true for low gain settings, whilst the former is unlikely to be always a convenient field situation. The ORACLE/CYCLOPS approach permits prediction of field performance as a function of gain settings, etc. but relies on a value of part perimeter for interrogation which gets smaller for higher order tasks. The main limitation is in the accuracy to which the part perimeter for a given task can be specified. Facilities are available for detailed exploration of critical feature information transmission to the perceptual levels of the cortex through the matrix processing model VISIVE and variants (e.g. Refs. 3 & 4). These are meant to be used in conjunction with ORACLE/CYCLOPS.

iii) The Johnson criteria are claimed to have been validated in a range of studies by NVL, but no details can be obtained on the range of equipment and equipment settings used in the validation studies nor on the actual spread of results. Some predictions of practical results using MRTD/Johnson criteria produce markedly low values. Part perimeter values for ORACLE/CYCLOPS have only received very limited validation.

iv) The MRTD approach is limited, by definition, to foveal interrogation tasks. The ORACLE/CYCLOPS approach is applicable to a wide range of visual tasks, provided that they can be specified adequately. MRTD's can be predicted using a modified form of ORACLE. Equally, if of any value, ORACLE may be used to compute effective MRTD's for other than foveal viewing and for low display gain settings.

v) It is suspected, although cannot be proven, that the Johnson criteria were set up using displays with prominent rasters. For aperiodic objects this would tend to destroy visual information, whereas for bar patterns with bars orthogonal to the raster there would be little degradation. The ORACLE/CYCLOPS model currently assumes a non-visible raster. Work is in progress to attempt to provide a raster degradation factor (although we strongly advise against use of visible raster where possible since optimum information transfer is obtained with a just imperceptible raster - c.f. Biberman, Ref.5).

3. APPLICABILITY

For the purpose of comparing existing systems either theoretical or experimental MRTD derivation will often be sufficient provided that any distributed performance across the displays is considered and provide that there are no marked differences in raster structure. In general for similar rasters a system having an overall superior MRTD will perform best in all situations. Only if the MRTD's of such systems cross at some intermediate frequency, or if such systems have very different extents of distributed performance, are there potential problems, since in these cases the rank ordering will depend on the range of applications. For systems having very different raster presentations the MRTD alone cannot be considered an adequate comparative measure since it only explores performance orthogonal to the rasters.
If MRTD is sufficient then it may be calculated equally well by any variant

For purposes of assessing the absolute performance of future systems, or for designing systems to meet a GST, a much wider scale of modelling must be employed. In general this will involve both absolute predictions of foveal performance and prediction of defined search performance.

Foveal performance may be approached via MRTD and Johnson criteria provided that the latter are believed and assuming a high display gain setting. Alternatively it may be approached using ORACLE, including allowance for variable display gain, provided that part perimeter values may be believed. Work is currently in progress to establish the accuracy and universality of part perimeter values currently employed and to establish the magnitude and form of information suppression due to visible raster.

The prediction of defined search performance must involve peripheral vision, single-glimpse visual performance and such factors as interaction of distributed display quality, scene structure and peripheral vision. The ORACLE/CYCLOPS form of vision modelling, backed up by search modelling concepts (Ref.7) and the VISIVE group of matrix neural processing models, has been specifically developed to handle such situations. In order to be used to predict field performance in specified search situations it may be tailored to take as inputs either objective system performance measures such as MTF, NETD, system gain, etc. or mixed performance measures including MRTD. In the latter case, since the whole concept of the basic ORACLE model is related to the detection of luminance difference signals (which contain information distributed throughout frequency space), the only route from MRTD to field performance is via prediction of system MTF, then to area under the MTF (the Fourier transform of the peak strength of the system line spread function) and hence to the threshold function for aperiodic objects. The apparently much simpler route frequently used from MRTD through the Johnson criteria is believed to be only an approximation which yields reasonable predictions due to a fortunate similarity in progressive function form of the MRTD curve and the contrast/reciprocal size curve for aperiodic objects over a limited range of intermediate frequencies (reciprocal sizes). Attempts to simplify the ORACLE equation for such intermediate conditions result either in dangerous over-simplification, with attendant severe limitations on applicability, or in simplified but still somewhat complicated formulations. Since for fixed viewing conditions, retinal position, etc. the basic ORACLE equation is readily solved by means of a very simple computer

An alternative capability of the ORACLE/CYCLOPS concept for future system assessment is to turn the model inside out such that a defined set of field requirements are put in and the equations finally solved for such factors as MTF, NETD, etc.. In this way an envelope of objective limiting performance figures (MTF, NETD, magnification, display field of view, etc.) may be generated to suit any given design aim (see Ref.8).

4. CONCLUSIONS

It may be concluded that for comparison of existing systems having similar rasters the application of MRTD as a direct relative measure of goodness may be adequate provided that due attention is paid to distributed performance. For absolute predictions of performance of future systems at the design stage, or for specification of bounds of sighting system performance to meet a given GST, a much more versatile modelling acknowledging both peripheral performance and search is required. The ORACLE/CYCLOPS approach has been developed for just such situations. This approach is continuously being updated and refined and can, if necessary, be used not only to predict field performance but also to predict MRTD. It may be employed starting with either objective input such as MTF and NETD or subjective inputs such as MRTD. For comparison of systems having very different raster presentations the MRTD approach is inadequate and the ORACLE/CYCLOPS approach is in need of a refinement to allow fully for raster effects.

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